# Variation in Visual World Performance is Related to Both Verbal and Visual Memory

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## I. Purpose

A visual world (VW) eye-tracking paradigm [1] is used to examine relations between differences in verbal memory, visual memory and vocabulary knowledge and the ability to integrate semantic information across words and with visual context. Our goal is to achieve a deeper understanding of the true range of variation in human language processing skill and its correlates. The particular focus of this study is variation in online visual--verbal integration time. We recruited participants from adult education centers and community colleges serving urban neighborhoods. The location of the study has one of the largest minority--majority educational achievement gaps in the USA.

Participants were assessed for vocabulary knowledge, verbal memory, visual memory, full-scale IQ (FSIQ) and other measures of language and cognitive function (e.g., reading comprehension, listening comprehension, phonological awareness, decoding skill, print experience). We do not have room to fully explore all measures in this short preliminary report, but point out that this population does tend to lag in language and other cognitive domains.

## II. Method

**PARTICIPANTS**

We recruited young adults (N=64, 34 female), aged 16 to 24 years. Participants were assessed for verbal memory, visual memory, vocabulary and a variety of other indices targeting reading comprehension and related abilities. Participant sample includes a wider range of such abilities than would be found in a typical sample of university students [2].

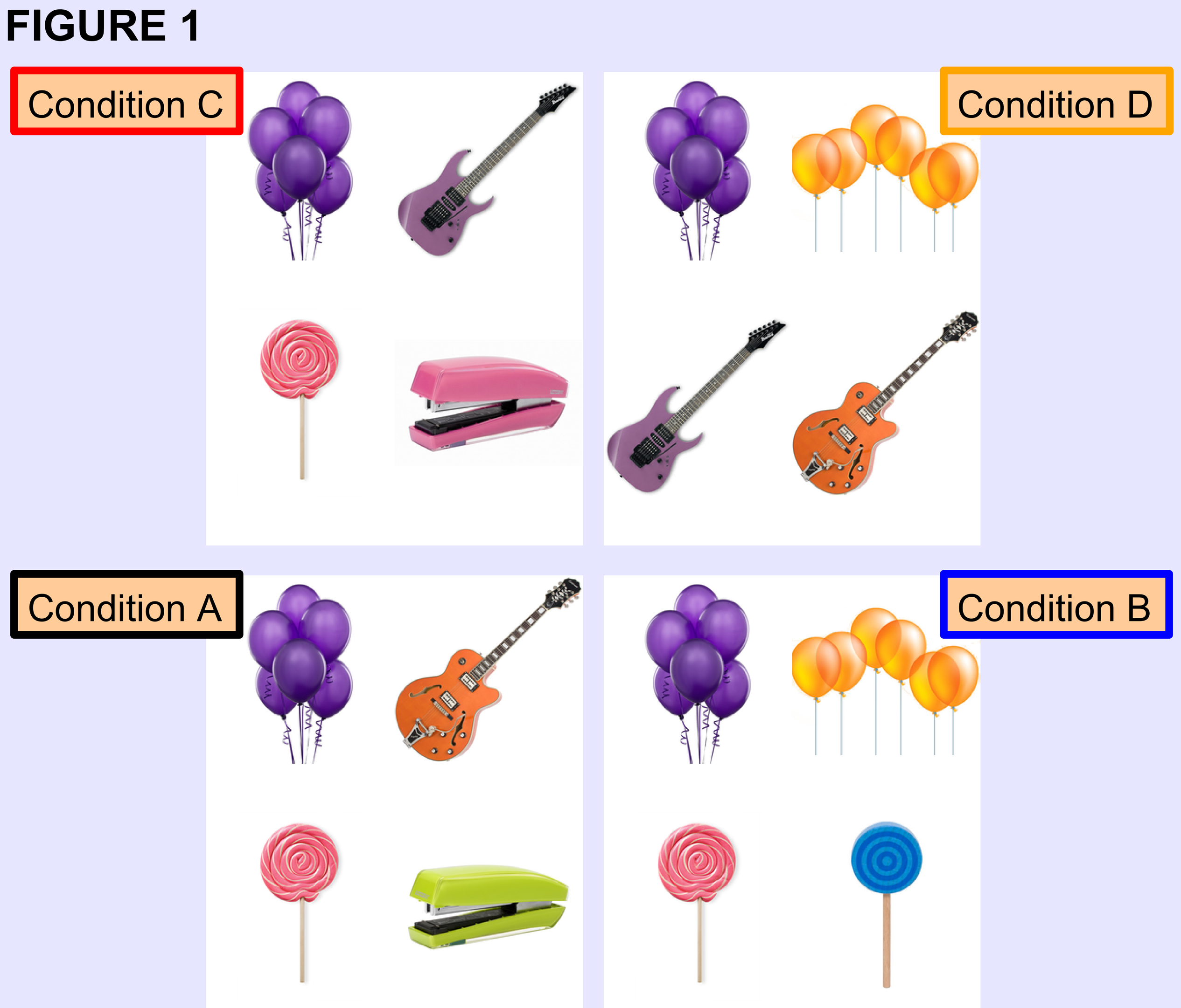
**TABLE 1: Summary of Individual Difference Scores**

| | Mean | SD |
|---|---|---|
| Age (years) | 19.79 | 2.50 |
| Verbal Memory (sentence span) | 37.66 | 8.95 |
| Visual Memory (corsi blocks) | 4.94 | 0.97 |
| Vocabulary (PPVT) | 155.03 | 20.45 |
| FSIQ (WASI) | 88.42 | 10.97 |

**PROCEDURE**

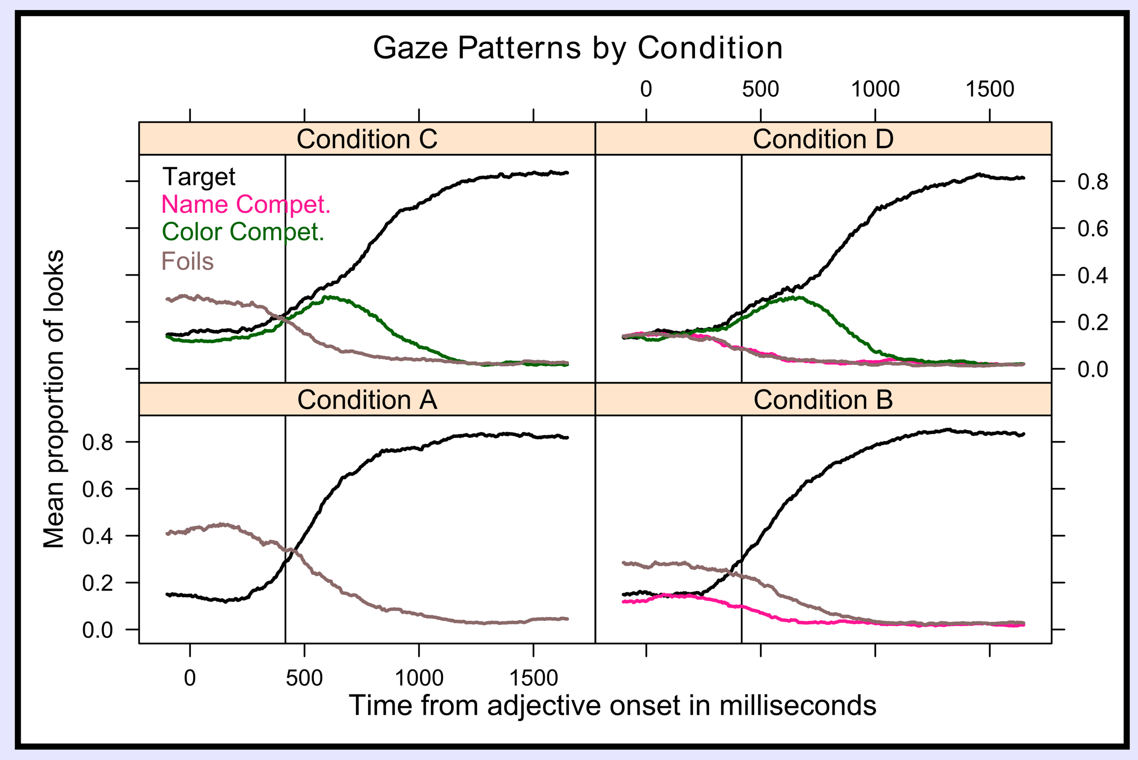
The VW procedure consists of a 4 picture display (Figure 1). Four conditions instantiate the interaction of 2 factors. First is early vs. late resolution: in the 'early' condition (A & B) targets can be identified by color alone; targets in the 'late' condition (C & D) cannot be identified until the noun is heard. The second factor is the presence vs. absence of a name competitor for the target. Name competitor displays (B & D), include an object of the same type as the target, but of a different color; in other displays the target picture is unique with respect to name (A & C; cf. [3]). Adjectives are common color terms and nouns are names of common objects. Participants follow instructions to (e.g.) "Point to the purple balloons."

**FIGURE 1**



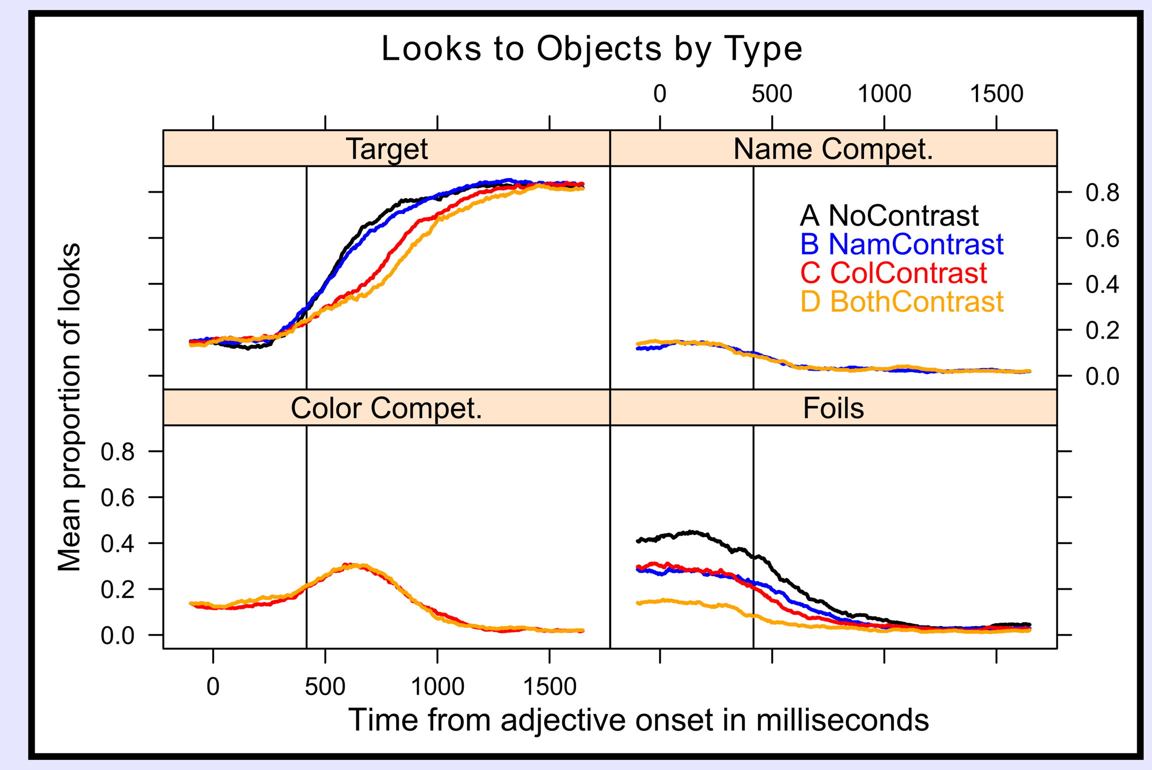

## III. Result

FIGURE 2: Looks to each picture type plotted separately for each condition, averaged across all subjects.




Vertical line in each panel (at about 416 ms) indicates average Noun onset time.

FIGURE 3: Same curves as Fig. 2, grouped by picture type.



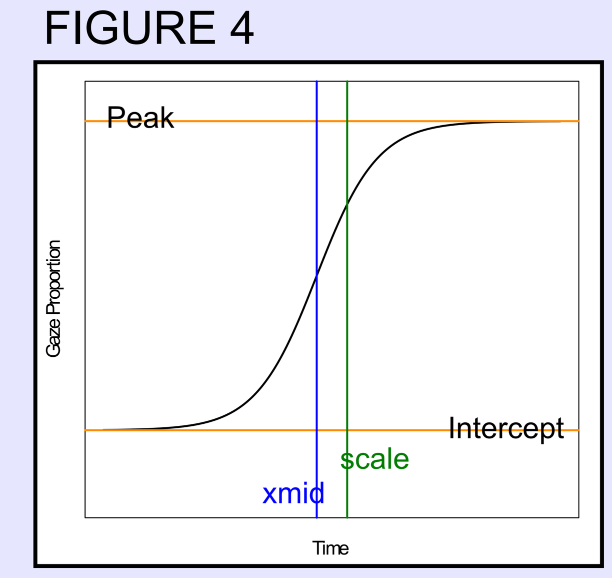

Differences in proportion of looks to FOILS across conditions is due to the different numbers of foils (3 in condition A; 2 in B & C; 1 in D).

SUMMARY: Figure 3 shows a main effect of point of disambiguation due to adjective (early vs. late), no main effect of the presence vs. absence of a Name competitor, and no interaction between the two.

ANALYTIC APPROACH

1. We used a mixed-effects growth model to fit a logistic function [y=intercept+(peak-intercept) / (1+exp((xmid-time)/scale))] to the proportion of looks to target pictures in each condition as a function of time [4-6]. The model includes random effects for these parameters for each subject-by-condition partition. Time 0 in the model corresponds to the onset of the adjective in the speech stimulus.
2. Random coefficients were extracted from the growth model and multiple regression was used to identify associations between individual variation in VW performance and measures of IQ, vocabulary, verbal memory and visual memory.

FIGURE 4




INDIVIDUAL DIFFERENCES

1. For each condition, 4 multiple regression models targeted VW coefficients (*intercept*, *peak*, *xmid*, *scale*; see Figure 4). FSIQ, vocabulary, verbal memory and visual memory were used as independent measures.
2. No model predicted reliable variance in VW coefficients for conditions B & D. These two conditions included Name competitors.
3. In condition A, our measure of visual memory showed a reliable negative partial correlation with coefficient *scale* (t= -2.04, p= .046), accounting for a unique 6.5% of variance.

   Higher values of *scale* entail a steeper 'slope' to the sigmoid function. So, the negative association between *scale* and visual memory scores indicates that individuals with better scores converge on target pictures more quickly than those with lower scores.

VISUAL MEMORY ←

4. In condition C, verbal memory (auditory sentence span) showed reliable positive partial correlations with coefficients *intercept* (t= 2.37, p= .020) where it accounts for a unique 8.5% of variance, and *xmid* (t= 2.98, p= .004) accounting for a unique 12.9% of variance.

   The association between verbal memory and coefficient *A* is unexpected and we have no ready explanation. We speculate that it may be due either to uncontrolled properties of the visual stimuli or to differential sensitivity to coarticulation information in the word preceding the adjective ('the'); see conclusion.

   The positive association between verbal memory and *xmid* indicates that individuals with higher memory scores begin their looks to targets more readily than those with lower memory scores.

VERBAL MEMORY ←

## IV. Conclusions

This study demonstrates non-random variation in the ability of adult listeners with verbal abilities in the normal range to rapidly integrate meaning across words even in the case of simple adjective--noun composition using common nouns and common color terms.

Previous work from our group using the VW paradigm to study the effect of misleading coarticulation information on looking times found that individuals with lower vocabulary scores were more affected by mismatched coarticulation information [7].

Together these results point up the importance of efficient semantic and phonological processing to online language comprehension even for speech containing simple vocabulary and low compositional demands.

## References:

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